

Chapter 1

Introduction

While the typical citizen may think otherwise, the modern municipal solid waste (MSW) landfill has evolved into a sophisticated facility. The state-of-the-art landfill can be loosely categorized into four classes. The secure landfill tends to entomb wastes, perhaps postponing any environmental impact to the future when environmental controls and safeguards initially provided fail. The monofill accepts waste which cannot be processed otherwise through resource recovery, composting, or incineration. These materials tend to be inert and may be more easily assimilated by the environment. At present, the monofill is used for disposal of combustion ash, construction and demolition debris, and yard waste. The reusable landfill permits excavation of the landfill contents to recover metals, glass, plastics, other combustibles, compost and, potentially, the site itself following a lengthy stabilization period. A fourth, emerging landfill type, is the bioreactor landfill, which is operated in a manner to minimize environmental impact while optimizing waste degradation processes.

The landfill, as we know it, has evolved from a long tradition of land disposal of MSW, dating back to prehistoric times. Problems with land disposal began as society developed and population density increased. Land disposal of waste (often as open dumps) was subject to aesthetic, safety, and health problems which prompted innovations in design and operation. Environmental impacts associated with MSW landfills have complicated siting, construction, and operation of the modern landfill. Production of leachate has lead to documented cases of groundwater and surface water pollution. Landfill gas emissions can lead to malodorous circumstances, adverse health effects, explosive conditions, and global warming. Traffic, dust, animal and insect vectors of disease, and noise are often objectionable to nearby neighbors.

Ideally, land should be a repository exclusively for inert "earthlike" materials that can be assimilated without adverse environmental impact, a conviction held by landfill regulators, designers, and operators throughout the world (Carra and Cossu, 1990). However, successful application of this concept requires extensive waste processing to develop an acceptable product for land disposal, and faces challenges related to public opposition, economics, waste handling, and transportation of recovered materials. The most reasonable scenario for success appears to be a MSW management park, where regional facilities for managing waste, from separation to resource recovery/reuse to incineration to landfilling, would be collectively sited.

While disposal solely of inert materials may be an admirable objective, it will be some time, if ever, before this concept can be universally applied. It is likely, therefore, that landfills will continue to receive a variety of materials with potential for environmental impact. A second global consensus is that where leachable materials are land disposed, impenetrable barriers must be provided and waste stabilization must be enhanced and accelerated so as to occur within the life of these barriers, that is, the landfill must be designed and operated as a bioreactor. Additional advantages of the bioreactor landfill include increased gas production rates over a shorter duration, improved leachate quality, and more rapid landfill settlement. Clearly, to successfully operate the bioreactor landfill, it will be necessary to implement a variety of control mechanisms.

Under proper conditions, the rate of MSW biodegradation can be stimulated and enhanced. Environmental conditions which most significantly impact biodegradation include pH, temperature, nutrients, absence of toxins, moisture content, particle size, and oxidation-reduction potential. One of the most critical parameters affecting MSW biodegradation has been found to be moisture content. Moisture content can be most practically controlled via leachate recirculation. Leachate recirculation involves the return of liquid emanating from active or closed landfills back to the landfill and provides a means of optimizing environmental conditions within the landfill to provide enhanced stabilization of landfill contents as well as treatment of moisture moving through the fill. The advantages of leachate recirculation include distribution of nutrients and enzymes, pH buffering, dilution of inhibitory compounds, recycling and distribution of methanogens, liquid storage, and evaporation opportunities at low additional construction and operating cost. It has been suggested that leachate recirculation can reduce the time required for landfill stabilization from several decades to two to three years (Pohland, 1975). Figure 1-1 provides a schematic of the landfill bioreactor.

This report documents results of research efforts to demonstrate full-scale operation of a municipal solid waste landfill bioreactor such that it poses minimal risk to human health and the environment. Chapter 2 provides an executive summary of this report. Chapter 3 summarizes the regulatory status of the bioreactor landfill. A review of laboratory, pilot, and full-scale investigations of the bioreactor landfill in the technical literature is given in Chapter 4. Chapter 5 describes design and operating criteria for second-generation full-scale bioreactors constructed over the last five years. Chapter 6 provides an overview of the impact of bioreactor operation on landfill leachate and gas characteristics. Chapters 7 and 8 summarize state-of-the-art design and operating criteria for the bioreactor landfill, respectively.

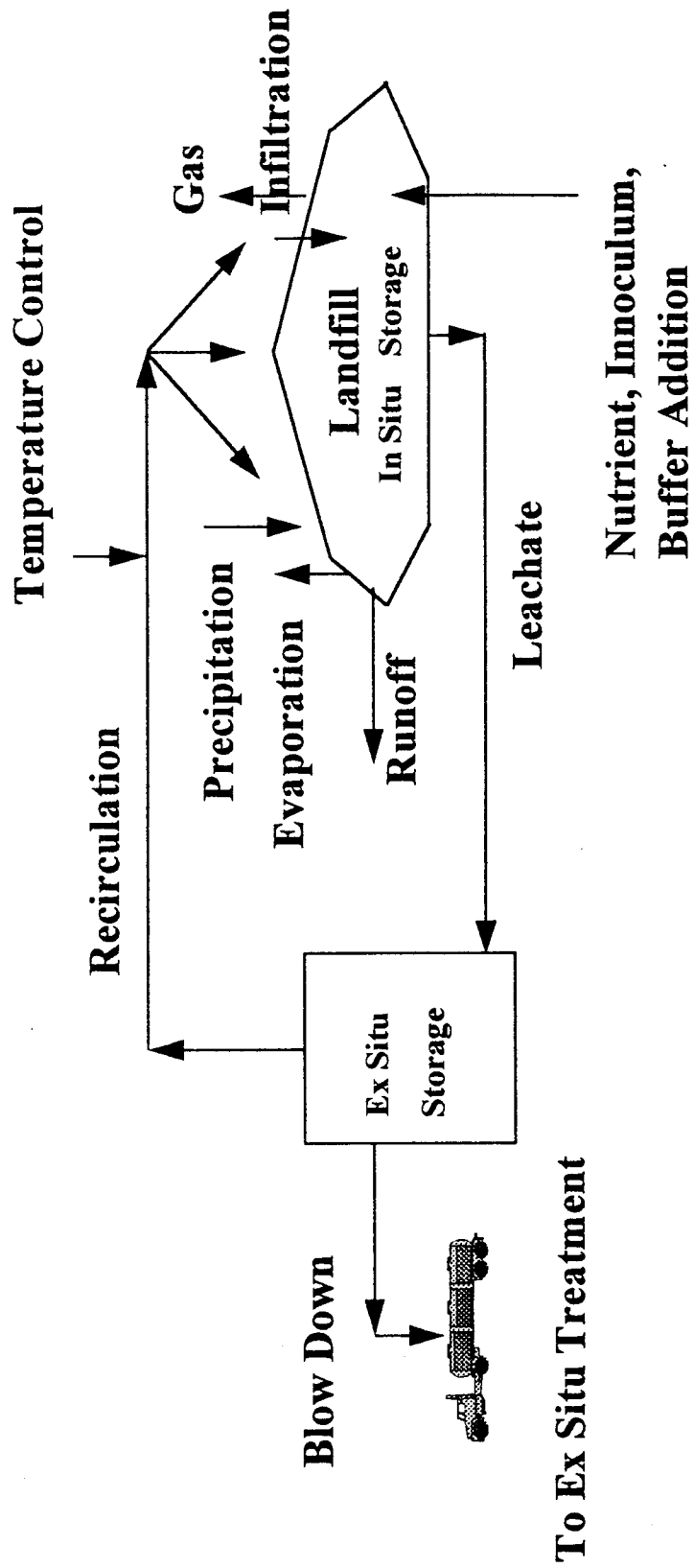


Figure 1-1. Schematic diagram of the landfill bioreactor.